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$T = t + t_1 = \sqrt{\frac{r}{g}} \left( \frac{1}{6} \pi + 2\sqrt{2} - \sqrt{3} + 2 \log \frac{2 + \sqrt{2}}{1 + \sqrt{3}} \right) = 1666.673 \text{ seconds} = 27 \text{ minutes, } 46.673 \text{ seconds.}$

$v_3 = 44869.668 \text{ feet per second} = 8.498 \text{ miles} = 8\frac{1}{2} \text{ miles per second, nearly.}$

When  $v_1 = r\sqrt{(2g/a)}$ ,  $v_2 = \sqrt{(2gr)}$ , and the velocity of arriving at the surface is independent of  $a$ , the distance from the center.

## NUMBER THEORY AND DIOPHANTINE ANALYSIS.

163. Proposed by PROFESSOR R. D. CARMICHAEL, Anniston, Ala.

Prove that the equation  $y^n = mx + 1$  always has at least one positive integer solution (different from  $y=1$ ,  $x=0$ ), whatever integer values  $m$  and  $n$  may have.

Solution by S. LEFSEHETZ, Pittsburg, Pa.

The following solution is evident:

$$y = (m+1)^n, \quad x = \frac{(m+1)^n - 1}{m}.$$

To find all solutions, we remark that it is enough to find all values of  $y$  such that  $y^n \equiv 1 \pmod{m}$ . Let  $f$  be a divisor of  $\phi(m)$ , a number to which  $f$  appertains. Then  $a^f \equiv 1 \pmod{m}$ . If also  $a^n \equiv 1 \pmod{m}$ , we must have  $n \equiv 0 \pmod{f}$ . Hence,  $f$  is a divisor of  $dv[n, \phi(m)]$ . Therefore we take the  $\phi(m)$  numbers smaller than  $m$  and prime to it, we form the exponents to which they appertain and keep them if their exponents divide  $dv[n, \phi(m)]$ . If  $x$  be such a value,  $y = x + km$  is a solution, the corresponding value of  $x$  being  $\frac{y^n - 1}{m}$ , which is integral since  $y^n \equiv 1 \pmod{m}$ .

## AVERAGE AND PROBABILITY.

200. Proposed by PROFESSOR R. D. CARMICHAEL, Anniston, Ala.

A line  $AB=l$  is extended to  $P$  making  $BP=p$ . If a point  $D$  is taken at random in  $BP$ , what is the mean value of  $AD \cdot DP$ ?

Solution by J. EDWARD SANDERS, Weather Bureau, Chicago, Ill.

Let  $x=BD$ . Then  $AD=l+x$ ,  $DP=p-x$ , and  $AD \cdot DP = (l+x)(p-x)$ .

$$\begin{aligned} \therefore M &= \int_0^p (l+x)(p-x) dx / \int_0^p dx = \frac{1}{p} \int_0^p [lp + (p-l)x - x^2] dx \\ &= \frac{1}{6} p(3l+p). \end{aligned}$$

Also solved by G. B. M. Zerr.